COPPER PIPING CORROSION:
A PROBLEM FOR SAN FRANCISCO BAY

The Palo Alto Regional Water Quality Control Plant (RWQCP) is required to meet extremely stringent copper limits for discharge to San Francisco Bay. Approximately 71% of the copper discharged from the RWQCP comes from corrosion of copper pipes and cooling equipment in homes and businesses. During 1995, the RWQCP conducted an investigation of copper piping corrosion and potential corrosion reduction measures to ensure that this source of copper is controlled to the maximum extent practical.

Because most of the RWQCP service area receives Hetch-Hetchy water from the San Francisco Water District, the study included efforts focusing on reducing copper corrosion from this specific water supply, as well as investigation of general corrosion reduction measures. Although the Water District currently already adds a chemical to reduce the corrosivity (increase pH) of the water, it is somewhat more corrosive than other regional water supplies.

The RWQCP retained Kennedy/Jenks Consultants to conduct the technical investigation. The results of the study, were published in a series of four reports described below. The City of San Jose jointly funded one report, which investigates alternatives to copper piping and faucets.

Linear Polarization Studies and Corrosion Rate Estimates—This report provides details on chemical testing of drinking water samples in samples of copper piping; estimates daily wastewater discharge of copper due to corrosion of copper piping; and includes the test data to support a recommendation that if the City of Palo Alto decides to add corrosion inhibitor to its water supply that it use orthophosphate at 1.0 milligram per liter (as phosphate).

Copper Corrosion Reductions Associated with the Design and Construction Practices of Piping Systems, Heating Systems, Cooling Systems, and Hot Water Circulating Systems—This report, which identified and evaluated alternatives to current practices, found that there are few situations where use of non-copper piping would be both legal and desirable, but made specific recommendations for:

- design, installation, and operation of cooling water systems
- operation of recirculating hot water systems, and
- installation of copper water piping.

The study found no practical alternatives to copper pipe and brass faucets exist that are suitable for widespread use: plastic pipe is not legally allowed for most uses (in California); stainless steel has limited availability and is very expensive; and coated or pre-treated copper pipe are not generally available.

Study results indicate that small reductions in corrosion rates can be achieved through implementation of a set of best management practices that are recommended by the International Association of Plumbing and Mechanical Officials (IAPMO). Pipe reaming, cleaning, use of certain solders and fluxes, and proper soldering technique can decrease corrosion, while helping to limit piping leaks in the long-term. Following recommended water flow velocities (lower than permissible levels), reducing bends in piping, and keeping hot water system temperature to recommended levels (and no higher) can also reduce piping corrosion. Santa Clara Valley wastewater treatment plants are working to educate plumbers about these practices and the fact that they reduce both copper discharges to the Bay and pipe failure rates.

Copper Loading from Cooling Towers and Potable Hot Water Circulation Systems— Systems that recirculate hot water continuously to provide "instant" hot water at the top raise unique corrosion issues. Cooling water systems also provide the opportunity for exacerbated corrosion. This report:

- summarizes detailed surveys of regional cooling and recirculating hot water systems
- estimates that copper discharges from cooling water systems comprise about 6 percent of total influent copper,
- projects that copper discharged from circulating hot water systems may be as much of 7 percent of total influent copper (this estimate includes contributions from drinking water supply and ordinary piping corrosion, not just the excess corrosion due to circulating the hot water).

Copper Corrosion Reduction Associated with the Addition of a Chemical Corrosion Inhibitor to the City of Palo Alto's Distribution System—This feasibility study for corrosion inhibitor addition:

- summarizes the many corrosion inhibitor studies performed on the Palo Alto water supply that form the basis for recommending a specific corrosion inhibitor should local corrosion reduction actions be necessary;
- evaluates the potential effects of corrosion inhibitor addition on water quality, human health, and surface water quality;
- contains preliminary design drawings for facilities that would be needed to add corrosion inhibitor to the Palo Alto water supply; and
- estimates the costs for inhibitor addition.

The study concludes that addition of 1 mg/l orthophosphate to control corrosion in Palo Alto's water supply would be technically feasible and potentially be a cost-effective method of reducing discharges of copper to the RWQCP.

Corrosion Pollution Prevention Programs

A range of control measures from education to ordinance restrictions are possible outcomes of the study. On the basis of study results, the RWQCP has initiated additional pollution prevention programs to reduce discharges of copper from corrosion, and has created a contingency plan listing possible future actions that may be necessary depending on future Bay discharge standards (these standards are based on Bay water quality standards, which are currently under review by regulatory agencies.) A copy of the RWQCP's corrosion Action Plan is attached.

RWQCP COPPER CORROSION ACTION PLAN

Item	Actions In Progress	Possible Actions (not recommended at this time)
Addition of Corrosion Inhibitor to Water Supply	Monitor drinking water corrosion reduction plan approval process at California Department of Health Services and actions to control corrosion being taken by the San Francisco Water Department. Work with Palo Alto Utilities Department to test identified corrosion inhibitor strategy.	Initiate capitol improvement projects for orthophosphate addition to water supply. *Possible triggers for this action:* • *need for copper corrosion reduction (depends on discharge standard);* • *need for lead corrosion reduction (depends on Drinking Water regulatory status).*
Use of Non-Copper Piping Materials	Increase public awareness of issue through public information materials. *Published "Get the Connection Between Your Plumbing and Pollution in the Bay," which is being distributed to residents.* Encourage facility managers and design engineers to use stainless steel and plastic piping for authorized uses (e.g., exterior and industrial equipment applications). *This will be included in the guidance for architects, engineers, and facility managers to be published in 1996.*	Allow use of CPVC piping in buildings (this action would only be feasible if the state makes CPVC an allowable option for these occupancies). Ban use of copper pipe in new buildings (this action would only be feasible if the above action was taken.). *Possible triggers for these actions:* • *state has allowed use of CPVC;* • *RWQCP has continued copper compliance problem (based on copper standard after re-evaluation);* • *other reasonable & feasible corrosion control and other source control measures already implemented.*
Pipe Installation	Provide Best Management Practices (BMPs) to plumbers: • recommending use of IAMPO BMPs and pipe cleanliness checks (stress corrosion reduction actions and pipe failure reductions), and • identifying fluxes and solders that make easier, better joints. *Published "Copper Plumbing and the Health of the Bay: Guidelines for Plumbers," which was distributed to plumbers.*	Solicit feedback from plumbers on flux and solder recommendations. If feasible, add solder and flux restrictions and IAMPO BMPs to Ordinances. Implement regional training certification program for plumbers. *Possible trigger for implementation: continued copper compliance problem (based on copper standard after re-evaluation).*

Item	Actions in Progress	Possible Actions (not recommended at this time)
Building Design: **- piping**	In the BMP booklet for plumbers and in information for facility managers and design engineers, recommend use of lower pipe velocities endorsed by IAPMO and others. Particularly encourage using these lower velocities for recirculating hot water systems. *Included in publications described above.*	Adopt IAMPO/AWWARF pipe velocity recommendations as part of city code (for copper piping only). *Possible trigger for implementation: continued copper compliance problem (based on copper standard after re-evaluation).*
- water heaters/ boilers	In information for facilities managers and in communications with local homeowners, encourage operating hot water systems at—not above—recommended temperatures. *Included in publications described above.*	Provide information to facilities managers, suggesting operation at lower temperatures (solicit comments from appropriate parties first; health concerns must be addressed). *Possible trigger for implementation: continued copper compliance problem (based on copper standard after re-evaluation).*
- cooling systems and heat exchangers	Via revisions to cooling water system BMPs and through information prepared for facility managers and design engineers, encourage closed systems and non-copper materials use for cooling towers and heat exchangers in appropriate cases. Encourage use of non-copper piping in open systems. Included in revised Cooling Water System BMP booklet. Conduct plan review and suggest changes that would reduce corrosion during building permit issuance process. Implemented. Utilize building permit issuance process to provide corrosion reduction suggestions in Mountain View as is currently done in Palo Alto. *Implemented.*	Modify ordinances to prohibit open cooling towers, with exception provision for situations where cost exceeds benefits (e.g., when structural reinforcement of existing building needed to handle weight of closed system). Modify ordinances to prohibit copper heat exchangers (cooling and heating uses). Modify ordinances to prohibit use of copper materials that contact water in any cooling system with a routine discharge. *Possible trigger for implementation: continued copper compliance problem (based on copper standard after re-evaluation).*